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REMEDIAL INVESTIGATION
SAMPLING AND ANALYSIS PLAN
for
MIDWAY LANDFILL
KENT, WASHINGTON

APRIL 2, 1986

State of Washington
Department of Ecology
Office of
Hazardous Substances and Air Quality Control

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Black & V
Engineers-Architects

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1.0 INTRODUCTION

This sampling plan has been developed for the Midway Landfill, located in the City of Kent, Washington, as part of the remedial investigation and feasibility study being conducted for the site. The sampling program developed for the site is designed to provide the data necessary to formulate and evaluate alternative remedial actions and to develop the conceptual design(s) of the preferred remedial action for final site remediation, consistent with State (including Chapter 70.105A RCW), Federal (including CERCLA, RCRA, TSCA), and local policies and guidelines designed to protect human health and the environment.

1.1 SITE LOCATION AND DESCRIPTION

The Midway Landfill is a privately owned landfill that was operated by the City of Seattle Solid Waste Utility from 1966 to 1983. The site consists of approximately 60 acres, located at South 248th and Pacific Highway South, inside the City of Kent, and is approximately 16 miles south of Seattle. The site is bordered on the east by Interstate 5. The site was formerly the location of a gravel mining operation and a peat bog lake, Lake Mead. The regional setting and site boundaries are shown on Figure 1.

Although the facility was to be operated only as a non-putrescible landfill accepting demolition and transfer station wastes, it has been reported that unknown quantities of solvents, organic and inorganic chemicals, heavy metals, and contaminated dredge materials have been placed at Midway.

The presence of methane and other gases generated during the decomposition process of the landfill materials presents potential threats to human health and the environment at the site. Additionally, there is concern over the possible presence of organic vapors from solvents and other organic compounds allegedly disposed in the landfill.

The groundwater analysis performed on the site monitoring wells indicated the presence of heavy metals and organics contamination. The presence of methane gas in the landfill and migration of the gas off the property has also caused concern over safety issues for surrounding residences and businesses.

Currently, the Seattle Engineering Department is investigating options for closure of the site under State of Washington solid waste guidelines. As part of this effort, geotechnical and hydrological investigations were performed and alternatives for closure of the site have been developed. The Seattle Engineering Department has completed a series of field investigations at the landfill site since 1982, including a system of methane flares and standpipes throughout the facility, shallow and deep gas probe clusters for gas monitoring, and groundwater monitoring wells. Most recently, the City has directed the implementation of a gas control system which consists of a curtain of gas extraction wells around the perimeter of the site , a gas collection system of piping and headers, and temporary blowers and flares to burn the gas. The City is currently completing the system and will construct a single permenent blower and flare system to serve the gas collection system.

Recently, the Department of Ecology and the City of Seattle have installed off-site gas extraction wells to remove gas which has migrated off-site to the east and northwest of the landfill.

1.2 SCOPE OF FIELD ACTIVITIES

The field activities for the Remedial Investigation of Midway Landfill are described in this sampling plan. The scope of the field activities was developed based on an evaluation of existing information, identification of data gaps and the extent of data gaps, and the identification of the types and extent of data needed to formulate remedial action alternativies. Background information relating to the site and the results of previous sampling and monitoring efforts may be found in the "Forward Planning Document for Midway Landfill", dated March 7, 1985, prepared by Black & Veatch for the State of Washington, Department of Ecology.

Recent field investigations and evaluation efforts related to the gas migration problem have resulted in an accelerated schedule for additional RI activities with regard to gas related problems. This RI Sampling and Analysis Plan has been revised to complement ongoing gas related investigations conducted under other work assignments.

The following sections present a summary of the remedial investigation objectives, a brief description of data currently available, and a description of the field activities designed to obtain the data needed to meet the remedial investigation objectives. Included is a summary of the types of samples to be obtained, the numbers and locations of samples, sampling methods, and laboratory analyses. The Quality Assurance Project Plan, which describes sample handling, analytical chemistry, sample chain-of-custody, and other QA/QC procedures, is provided as a separate document, as is the Site Health and Safety Plan.

2.0 REMEDIAL INVESTIGATION FIELD ACTIVITIES

The purpose of the field activities phase of the remedial investigation for Midway Landfill is to obtain sufficient data to identify the magnitude and the extent of contaminant and gas migration and to assess remedial action alternatives during the feasibility study. The collection and review of all data developed during the investigation will be done in a legally defensible manner, in accordance with CERCLA guidelines.

The investigation will consist of activities to be conducted in four major areas: geologic investigations; hydrologic investigations including groundwater, surface water, and leachate; a gas emission/air quality investigation; and an investigation to identify receptors including initial endangerment assessment activities. In general, the technical objectives of the investigation include the following:

- Define subsurface stratigraphy and geohydrology at the Midway Landfill site.

- Define the nature and extent of water, air, and soils contamination at the Midway Landfill site to support a subsequent remedial action feasibility study.

- Define the nature and extent of landfill gas subsurface migration adjacent to the Midway Landfill site in support of current Initial Remedial Measures (IRM'S) and ongoing gas investigations.

- Determine the effectiveness of the gas control system implemented at the Midway Landfill site by the City of Seattle.

- Expand on the existing technical data base to determine adequacy of the proposed City of Seattle final closure plan for Midway Landfill.

- Further identify potential off-site contamination receptors adjacent to the Midway Landfill site.

2.1 GEOLOGIC INVESTIGATION

2.1.1 Subsurface Stratigraphy

2.1.1.1 Objectives

Definition of the subsurface stratigraphy at the Midway Landfill is critical in understanding the occurrence and movement of landfill contamination (landfill gas and leachate) at the site. Representative geologic samples collected from boreholes completed in and around the landfill (during installation of gas probes, leachate wells, or groundwater monitoring wells) provide the basis for identifying stratigraphic units and delineating the extent of these units over the site and contiguous areas. Geologic logs of boreholes are used to construct geologic cross sections of the site that depict subsurface conditions and describe key stratigraphic units.

2.1.1.2 Evaluation of Existing Data

The draft "Environmental Impact Statement for Closure-Midway Landfill", City of Seattle, 1985 includes cross sections through the landfill that utilize existing monitoring wells as control points. These cross sections delineate landfill materials and glacial strata beneath the fill area and adjacent properties, down to an elevation of about 225 feet above mean sea level. Stratigraphic identification and delineation of contacts between strata are estimated over much of the site, however, mainly due to the limited quality of geologic samples provided by the air rotary drilling technique that was utilized in installation of many of the monitoring wells and gas probes. The thickness and extent of the glacial units underlying the landfill and surrounding area need to be determined more accurately, especially the finer-grained strata (silts and clays) which appear to influence groundwater occurrence and movement. Subsurface conditions should also be defined beyond the boundaries of the landfill by utilizing geologic information from offsite monitoring wells, gas probe boreholes, and water supply wells.

2.1.1.3 Sample Collection and Analysis Rationale

Additional subsurface information will be obtained from new monitoring wells, leachate wells, and landfill gas probes to be installed in and around the landfill. Cable tool and hollow stem auger drilling methods will be employed to obtain representative geologic samples at regular depth intervals using standard ASTM split spoon methods. These new geologic data will be interpreted in conjunction with existing test boring information to further define subsurface conditions in the vicinity of the site. Details regarding locations, depths, and installation methods for new landfill gas probes and monitoring wells are described in subsequent sections of this sampling plan.

2.1.2 Soils Investigation

2.1.2.1 Objectives

The objective of soils investigations at the Midway Landfill site is determination of any soils contamination which has occurred due to past disposal practices at the site and any new soils contamination which may be occurring due to migration of contaminants off-site.

2.1.2.2 Existing Data

Near surface soils comprise the upper six feet of the study area. Records of boreholes indicate that there is no site cap on the landfill site itself, and that the fill generally consists of a dark gray to black mixture of decomposed paper, plastic, steel, wood, and some soil used for fill material or daily cover. Boreholes in the perimeter of the landfill show near surface soils consisting of brownish gray fine to coarse sands. The characteristics of "Terminal 5" sediments which were deposited at the site in recent years has been determined, and those materials do not appear to be dangerous wastes with respect to State of Washington dangerous waste criteria. Those sediments are currently stored on the surface of the landfill on an approximately one acre site, and apparently will be graded and covered as a part of the overall closure plan for the site prepared by the City of Seattle. The closure plan for the site will include final grading of the site, filling of the remaining pond areas at the site which currently create an infiltration problem into the fill material, and a final soil cap of relatively impermeable uncontaminated soil to retard infiltration.

2.1.2.3 Sample Collection and Analysis Rationale

No further sampling or analysis of existing on-site soils or the "Terminal 5" sediments will be completed as a part of the remedial investigation. Adequate data exists to define the quality of these geologic materials and the site closure plan will totally cover these materials with a cap of uncontaminated relatively impermeable soil.

Off-site soils have not been characterized to date with respect to contaminant migration from the Midway Landfill site. Soil contamination could occur locally due to leachate seeps originating from within the subsurface strata of the landfill material or from contaminated surface runoff. Therefore, soils samples from approximately 20 seep locations around the perimeter of the landfill will be obtained to characterize any potential soils contamination caused by leachate or surface water runoff. These samples will be obtained using a shallow soils coring device at the 0-2 foot depth in the immediate area of seeps which are discovered during the remedial investigation. Several soil cores from the immediate area of the seep will be composited to prepare a single homogenous soil sample for laboratory analysis. Each sample will be extracted in the laboratory and analyzed for those parameters listed in Table 6.

2.2 HYDROGEOLOGIC INVESTIGATION

2.2.1 Leachate Characterization

2.2.1.1 Objectives

The objectives of leachate characterization are (1) to determine the chemical characteristics of leachate by sampling of monitor wells and subsequent laboratory analysis, (2) to determine the distribution of leachate within and adjacent to the fill material, and (3) to determine hydrogeologic characteristics of the leachate for purposes of evaluating the potential for a future leachate withdrawal and treatment program.

Leachate samples are useful in landfill investigations to evaluate the chemical composition of the leachate as a source of groundwater contamination. Definition of key indicator parameters in leachate from a particular landfill can provide a means of tracking groundwater contamination away from the landfill. The distribution of leachate, as indicated by moisture content of geologic fill samples and leachate fluid level measurements, is important in evaluating the geometry of the leachate saturated zone and the potential for horizontal and vertical leachate migration. The ability to influence the distribution of leachate, as determined by pump tests and well drawdown tests, is important in evaluating the feasibility of leachate treatment or other appropriate remedial actions.

2.2.1.2 Evaluation of Existing Data

The draft "Environmental Impact Statement for Closure-Midway Landfill", (City of Seattle, 1985) presents fluid levels and chemical data from two wells completed in the landfill material. Fluid levels indicate that water is collecting in a perched condition above the local water table. Chemical data from leachate analysis shows elevated concentrations of typical leachate parameters (total dissolved solids, ammonia nitrogen, and iron). Although these data are useful, additional leachate wells installed in other parts of the landfill are needed to define fluid levels and leachate quality across the site.

2.2.1.3 Sample Collection and Analysis Rationale

A total of three additional leachate monitor wells will be installed within the Midway Landfill at the approximate locations shown on Figure 3. Borings will be completed using the hollow stem auger drilling method unless anticipated total depths of the borings are such that a different method is required. Final decision on boring location and drilling method will be made during detailed site planning activities. The anticipated depths and screened intervals of the leachate monitor wells are shown in Table 1. Each borehole will be drilled to a depth below the bottom of the fill sufficient to characterize till and advance outwash deposits. Geologic samples will be collected from the fill and the strata below the fill at 5-foot intervals. The zone below the fill will be backfilled with bentonite slurry grout through the hollow stem auger to prevent downward migration of leachate below the fill material. Subsequently, well development tests to determine landfill permeability will be performed. Test methods will be the same as those utilized on groundwater monitor wells. Also, fill samples will be tested for moisture content to determine the zone of saturation within the fill at the drilling locations.

all three One of the leachate monitor wells will be installed with a minimum 4-inch ID steel casing to allow higher flow rate pump testing for drawdown tests. Drawdown tests may be performed using the larger diameter leachate well to determine the area of influence of the well for leachate withdrawal as part of a future leachate withdrawal and treatment feasibility study. Additional leachate monitor wells or, if appropriate, on-site City of Seattle gas extraction wells will be used in conjunction with the withdrawal well to determine leachate drawdown characteristics. Decisions regarding the exact location of and specifications for the larger diameter leachate well will be made during detailed site planning activities. Drawdown tests will be conducted at a future date when all necessary facilities are in place and operational.

Leachate monitor wells will be sampled using the same methods and analyzed for the same parameters described in the groundwater monitoring section of this sampling plan (see Table 3).

2.2.2 Groundwater Hydrology and Characterization

2.2.2.1 Objectives

The major objectives of the groundwater portion of the hydrogeologic investigation are to determine the extent and migration rate of groundwater contamination at the Midway Landfill. This determination requires an understanding of the occurrence, movement, and quality of groundwater in the earth materials beneath and adjacent to the landfill. Properly constructed and located monitor wells provide geologic, water level, and water quality data. These data allow determination of horizontal groundwater flow directions, vertical groundwater gradients, groundwater migration rates, and groundwater quality, and enable the impacts of the landfill on the groundwater system to be evaluated.

2.2.2.2 Evaluation of Existing Data

The existing monitor well network on and adjacent to the landfill is shown in Figure 2. As noted in the Geologic Investigation section of this sampling plan, the existing data do not allow sufficient delineation of geologic units that may influence groundwater occurrence and movement in the vicinity of the landfill (sand/gravel versus silt/clay). In addition, the existing monitor well network does not allow adequate determination of groundwater flow directions in the water table aquifer, vertical groundwater gradients from the water table to deeper hydrogeologic units, or the extent of groundwater contamination from leachate generated by landfill. Records of water wells in the area have been utilized to compile a generalized regional groundwater flow map, and a water well inventory for the immediate vicinity of the landfill has been compiled by the City of Seattle. A water well inventory can provide useful offsite geologic information, and is also necessary to determine the potential impacts of ground water contamination on local water supply systems.

2.2.2.3 Sample Collection and Analysis Rationale

A. Water Well Inventory

An inventory of water wells within 1 mile of the landfill boundary will be compiled. The initial inventory will consist of tabulating water well records on file at Ecology and at the City of Seattle Engineering Department. Local municiplaities and utilities will be contacted as necessary to determine the buildings within 1 mile of the landfill that are served by a public or private water supply system.

Private wells no longer used for water supply may be accessible for water level and or water quality measurements. If necessary, contacts with individual land owners will be made to confirm locations of private wells. These efforts will be coordinated with the community relations officer for the project.

Locations of public supply, industrial, domestic, and other water wells will be plotted on a map, and the records of these wells will be compiled. The service areas of water utilities will also be delineated on this map. The map and associated well logs will be utilized to select off-site wells for possible water level measurements and sampling, and to assess the susceptibility of water supply wells to contamination by groundwater migrating offsite from the landfill.

B. Groundwater Monitor Well Installation

A total of 17 new groundwater monitor wells will be installed in the vicinity of the Midway Landfill, at approximate locations shown on Figure 3. A two-phased approach will be used to drill and install the wells, with wells W1-W8, W11, and W15 (along with the three leachate wells) included in the first phase. Subsequently, wells W9, W10, W12-W14, W16, and W17 will be drilled and installed. The two-phased approach will allow the wells in those areas deemed most critical to be installed on a fast-track basis. Some of these new wells will screen the uppermost water table, while selected wells will be drilled below the water table to determine geology and water levels with depth. The anticipated depths and screened intervals of new monitor wells are given in Table 1. Actual boring depths and screen intervals will be determined in the field by project team geotechnical engineers and hydrogeologists.

need to 9 in the first phase

In order to determine whether significant differences exist in the water quality between the upper water table and water table beneath the confining layer, dual completion wells will be placed at locations W1-W3, W5, W11, W13, and W15. Dual completion wells will be completed in a single boring, and one or two gas probes will be installed in selected monitor well boreholes. A schematic drawing of the proposed installation technique for dual completion wells and probes is shown in Figure 4.

The drilling techniques to be used include the hollow stem auger technique and the cable tool method. Although the hollow stem auger drilling technique provides excellent geologic samples, the method is generally limited to depths of about 100 feet. The method will not be applicable to all monitor well completions because the water table appears at depths of over 100 feet in portions of the site area. An alternate drilling technique that provides sufficient geologic sampling control is the cable tool method, which will be utilized to install monitor wells at depths beyond the capability of the hollow stem auger. Other drilling techniques including the "Odex" drilling method or variations of the air rotary method will be used if unusual or difficult drilling conditions are encountered.

Geologic samples will be collected during drilling of the boreholes. Samples will be collected at 5 foot intervals by driving a core sampler ahead of the borehole into undisturbed earth materials. The core sampler will be cleaned between uses with a detergent solution, followed by tap water and distilled water rinses.

The depth of monitor well completion will be selected based on the geologic characteristics and relative degree of saturation of formations penetrated. Screens in water table monitoring wells will be placed such that the tops are above the water table to allow for fluctuations. Upon reaching the appropriate depth, a 2-inch diameter PVC well screen and riser pipe will be installed through the auger (hollow stem) or casing (cable tool). The annulus around each well screen will be filled with an appropriately sized sand pack, followed by a bentonite pellet seal. A bentonite slurry grout seal will then be placed around the PVC casing up to land surface, or to the elevation of the next well or probe screen for dual completion wells. Each seal will be allowed sufficient time to set prior to continuing with additional borehole operations. The augers or casing will be pulled during the backfill process, ensuring that the sand and gravel pack and seal are securely installed.

The wells will be secured at land surface by an appropriate diameter steel protector pipe or a steel flush-mount valve box or monument, depending on the location of the well. A locking cap will be installed on each valve box or monument to provide security for well caps. A permanent water level measuring point will be inscribed on each PVC well casing, and this measuring point will be leveled by a licensed surveyor to the nearest 0.01 foot mean sea level datum during the ground survey task.

Augers and other down-hole components of the drilling rig will be steam cleaned prior to drilling at the site, between boreholes, and prior to leaving the site. Monitor well casings and screens will be steam cleaned prior to installation. Cuttings and fluids from the drilling operation will be stockpiled on the landfill property for appropriate disposal.

C. Hydraulic Conductivity Determinations

Selected core samples of sand and gravel strata will be submitted to a soils laboratory for grain size analysis. Selected fine grained strata (silt, clay) encountered in boreholes will be sampled with a Shelby tube and tested for vertical hydraulic conductivity. Slug tests (rising and falling head) will be performed on all new monitoring wells to determine hydraulic conductivity of the water bearing formations penetrated.

D. Monitor Well Sampling

A dedicated bladder type displacement pump will be installed in each new monitor well, with access for manual measurement of water levels and attachment of equipment to power the pump. Existing monitor wells, and water supply wells used as background indicators, will be sampled using in-place pumps or appropriate bailers or pumping devices carried into the field.

Prior to initial sampling, a complete round of water level measurements will be made for all existing monitor wells and the volume of water standing in each casing will be calculated. An appropriate number of casing volumes will be evacuated prior to collecting the sample from the pump discharge or by bailer.

Prior to initiation of drilling activities, the 14 existing usable monitor wells (groundwater and leachate wells installed by the City of Seattle) will be sampled, including MW-1, MW-2A, MW-3, MW-4, MW-7, BH-1A, BH-1B, and BH-2 to BH-8. Additionally, two water wells identified from the water well inventory in the local area will be sampled to determine background water quality for the local groundwater resource. As each new groundwater and leachate well is completed and tested during the first phase of the drilling program, it will be initially sampled. Data from sampling of the existing and newly installed first phase wells will then provide information which will be used to finalize the location of second phase well installations. During the second phase of well installation, each well will be sampled as it is installed and developed. At the completion of the second phase of well installation, a second round of sampling will be conducted on all completed wells. Thus, at the conclusion of the monitor well installation program, each existing and newly installed well will have been sampled twice. Additional sampling rounds will then be conducted at intervals of approximately 12 weeks, allowing two weeks for well purging and sample collection and ten weeks for laboratory analysis of samples and interpretation of water quality data. Each monitor well and water supply well will be sampled a total of four times during the RI monitoring period, providing for seasonal variations in water quality and insuring a minimum number of samples for statistical evaluation of the data base.

Each sample will be tested for field parameters as soon as it is collected. Parameters will include pH, conductivity, and temperature. A no ~~Microtox~~ measurement will also be made to determine sample toxicity using indicator bacteria which react rapidly to toxic stress. A head space analysis will also be conducted on appropriate sample containers using the OVA GC/FID to detect total organics and to develop a chromatographic fingerprint of each sample. Samples for metals will be passed through a 0.45 micron filter prior to preservation with acid. Other samples will be placed in appropriate bottles and preserved according to the applicable analytical technique. All samples will be accompanied by a chain of custody form. Field measurements and well evacuation procedures will be recorded and included in the sampling record.

In addition to sample collection in monitor wells, water level measurements will be made on a monthly basis during the RI field investigation period at each existing well site. Water level measurements will also be made at the time of sampling of each well. only when sampled?

E. Water Sample Analysis

In addition to the field parameters and water level measured at the time of sample collection, groundwater and leachate samples will be analyzed in the laboratory for the parameters listed in Table 3. These parameters are based on constituents typically found in landfill leachate, and results of chemical analysis for samples from existing monitor wells at the Midway Landfill (City of Seattle, 1985). This list of parameters was selected to allow characterization of background water quality from water supply wells used for that purpose and delineation of contamination by landfill leachate.

Since hazardous substances or materials containing hazardous substances were disposed of at the landfill, priority pollutant analyses will be conducted on all initial samples in addition to those parameters included in the State of Washington Minimum Functional Standards for solid waste facilities. CERCLA guidance requires this approach to insure that site characterization bias is not introduced due to limited analysis of samples based on predicted or likely types and levels of contamination.

Upon receipt of the data from the initial analyses, an attempt will be made to correlate the degree of contamination present with indicator parameters. If such a correlation can be made, subsequent rounds of sampling may proceed with analysis of selected indicator parameters. Likely candidates for such parameters are indicated by the presence of an asterisk in Table 3. Decisions regarding parameter selection for groundwater and leachate samples will be made based on the water quality data accumulated during each sampling round and any trends which develop during subsequent rounds.

2.2.3 Surface Water Quality Investigation

The objectives of the surface water quality investigation at Midway Landfill are listed below:

- o evaluate the effect of infiltration upon leachate production
- o measure the quantity and quality of stormwater entering the landfill from the I-5 drainage area
- o determine what effect precipitation induces upon monitoring well levels and evaluate the effect on well levels from the on-site North and Middle ponds
- o identify and characterize surface seeps in the area adjacent to the landfill

2.2.3.1 Existing Data

A limited amount of data is available to quantify the amount of inflow resulting from the I-5 drainage system. Water level plots produced from monitor wells located on-site do not indicate a clear trend with relation to influent stormwater. The configuration of the drainage piping network within the landfill has not been clearly defined. Water quality measurements are available for the water that is trucked out of the landfill from the North Pond, but water level measurements have not been recorded for the pond.

At present two subsurface zones of saturation have been identified. One is above the water table and is a more or less isolated body of water. The other water table is much deeper and occurs within the Advance Outwash. However, both zones of saturation are believed to be recharged by precipitation falling in or around the landfill, from ponded surface water around the perimeter of the landfill, and from surface water directed into the landfill from east of I-5.

As previously reported ("Forward Planning Document, Midway Landfill", Black & Veatch, 1985), the landfill does not yield surface water out of its boundaries. The three ponds located on the property receive on and off-site drainage, as well as seeps from the fill material.

2.2.3.2 Sample Collection and Analysis Rationale

The sampling program for assessing surface water will include the use of flow measurements and physical/chemical analysis. To quantify the amount of storm water entering the site, flow meters will be placed at the culvert that enters the landfill at the northeastern corner, and at the manhole located east of the site, as indicated on Figure 7. The flow meters to be used will be level sensor meters (ISCO type) that will be triggered during storm events. It is expected that at a minimum, two storm events will be monitored. To assess whether influent stormwater induces changes in water quality, a limited analysis will be done on the composite storm-water samples. The parameters for the analyses are listed in Table 4. Information will be gathered at the meterological stations (addressed in a later Air Quality Monitoring section) concerning the duration of the storm events and the amount of rainfall and evaporation.

To evaluate the amount of runoff entering the Middle and North ponds, staff gauges will be placed in each pond with levels marked in 0.01-foot gradations. Daily readings of the gauges will be taken throughout the duration of field activities. A survey of the ponds will be completed to determine their volume and capacity. Samples will be collected and analyzed from each pond in accordance with the parameters summarized in Table 5.

A field reconnaissance survey will be made to determine where seeps are located around the landfill, and at what times seepage is present. Selected seeps and shallow gas probes which contain standing water will be sampled at least once for those compounds listed in Table 5. It is expected that approximately 20-25 liquid samples will be analyzed. In addition, approximately 20 soil samples will be collected at selected seeps or related off-site locations and analyzed for those parameters shown in Table 6.

2.3 GAS EMISSION AND AMBIENT AIR INVESTIGATIONS

Gases produced by the landfill require further characterization. Subsurface migration of methane has produced measured concentrations above the lower explosive limit in off-site residential and commercial buildings and in a high percentage of the off-site gas probes installed by the Department of Ecology and the City of Seattle. Emissions of methane, sulfides and organic compounds to ambient air may produce concentrations of some substances exceeding health and safety guidelines. Both gas transport pathways, subsurface and ambient air, require assessment during the undisturbed state as well as during remedial action efforts. These pathways will be addressed separately in this section.

The City of Seattle is currently implementing a gas control plan for Midway Landfill. The plan consists of installing an active gas venting system within the landfill and burning the gas in a flare system on the site. The system is currently operating on an interim basis with a more permanent exhaustor and flare system to be installed during the summer of 1986.

The Department of Ecology and the City of Seattle have also installed gas extraction systems at off-site locations to the east and northwest of the landfill site in an effort to remove subsurface gas in residential and business areas adjacent to the landfill boundary.

2.3.1 Subsurface Gas Migration

2.3.1.1 Objectives

The objectives of the sampling activities associated with subsurface gas migration are to:

- o expand the current landfill gas monitoring and sampling data base
- o determine effectiveness of the Midway Landfill gas control system
- o better estimate the present extent of landfill gas migration
- o identify migration conduits and landfill gas accumulation points
- o determine predominant transport mechanisms
- o determine compositional changes in gas as it migrates away from the landfill
- o determine effectiveness of off-site gas extraction systems and determine the need for additional off-site controls

2.3.1.2 Existing Data

Primary sources of existing data related to sursurface gas migration are: (1) periodic methane concentration measurements made by the Seattle Engineering Department at gas probes in the landfill and at several nearby areas, (2) weekly to biweekly methane concentration measurements made by City of Seattle consultants and local and state agencies at permanent gas probes outside the landfill, (3) gas composition measurements made by University of Washington personnel at three flares in the landfill (July, 1985), (4) well logs and construction diagrams prepared by Golder & Associates for the permanent gas probes outside the landfill (June, 1982 and July, 1985), (5) boring and installation logs for 73 shallow gas probes, 10 deep gas probe clusters, and two gas extraction wells installed by the Department of Ecology, and prepared by Black & Veatch and Hart-Crowser & Associates (Oct, 1985 to Feb, 1986), and (6) monitoring data for Ecology gas probes and gas extraction wells (Dec, 1985 to April, 1986).

This data, especially the methane concentrations at the permanent probes, has indicated that explosive conditions exist in a relatively large area surrounding the landfill. Measurements of combustible gas levels both on- and off-site have shown levels greater than 60 percent by volume. Although the data that are presently available do not allow the full extent of landfill gas migration to be estimated with a high level of confidence, methane concentrations do exceed the lower explosive limit (4 percent methane by volume) over distances greater than 1,000 feet from the landfill boundaries. Furthermore, laboratory analyses performed on samples from landfill flares indicate that the gas migrating away from the landfill could contain hydrogen sulfide, benzene, and other hydrocarbon compounds in concentrations sufficient to be of concern with respect to public health if emitted into ambient air.

Several gaps can be identified in the existing data. These gaps can be categorized into four general groups:

- data needed to determine total and partial pressure gradients in lines perpendicular to the landfill

- data pertaining to the composition of the landfill gas as it migrates from the site

- o data describing manmade and natural migration conduits and accumulation points, and the rate and extent of migration

- o data defining geologic stratigraphy and material properties

2.3.1.3 Sample Collection and Analysis Rationale

A. Gas Probe Installation

Seventy-three shallow (10 foot) gas probes and eleven deep (up to 100 foot) gas probe clusters have been installed recently by the Department of Ecology around the landfill to assess gas migration in the most important subsurface zone. The City of Seattle previously installed several gas probe clusters for the same purpose. Gas may be migrating through the soil and through various subsurface conduits such as utility pipes and vaults, emerging at breaks in the soil surface such as basement excavations and at sewer manholes and other utility surface projections, and through natural vents or cracks in the soil surface. The system of shallow probes is designed to detect gas in this upper subsurface zone in a 500-1,000 foot perimeter around the landfill in a systematic manner to detect explosive concentrations at or near the ground surface.

In addition to existing gas probe installations, at least ~~six~~ 10 additional clustered gas probes will be installed during the RI field investigation at locations of existing shallow probes as shown on Figure 3. Each probe cluster will consist of two probes screened at depths of approximately 10 to 50 and 60 to 100 feet, respectively, as summarized in Table 2. The locations of the new gas probe clusters will be selected to complement data being collected from existing probes and eight to ten deep gas probe clusters being installed under an ongoing separate work assignment related to gas migration issues.

A typical construction diagram for the probe clusters is presented in Figure 6. Borings for the probes will be drilled with a hollow stem auger or by the cable tool method with split spoon sampling at 5-foot depth intervals. Grain size analysis will be performed on selected samples. Each borehole will have a maximum depth of 100 feet and will be completed above the groundwater table. It is not expected that significant gas migration is occurring in the saturated zone below the uppermost water table.

Additional gas probes will be installed at selected monitor well locations as shown in Table 2 and in Figure 3. The exact number and locations for these probes will depend upon the stratigraphy that is observed at the time of installation. Monitor well probes will consist of 1/2 to 3/4-inch Schedule 80 PVC casing with 0.02 inch slotted screen. Length of screen will depend on the stratigraphy encountered at each borehole. Deeper probes will generally have longer screen intervals.

Each sampling interval will be surrounded with sand and gravel packs that will be sealed above and below with at least two feet of bentonite. The bentonite seal will be formed from bentonite pellets or from a finer granulated bentonite material to ensure proper placement around the casings and a secure seal to prevent interzonal migration within the borehole.

B. Gas Probe Monitoring and Sampling

Landfill gas monitoring is currently being conducted for shallow and deep probes and for selected surface locations in residential and commercial buildings under the direction of the Department of Ecology and City of Seattle Engineering Department. Monitoring for these locations is limited primarily to combustible gas concentration with the objectives of identifying areas where explosive gas concentrations may exist and determining extent of gas migration. The location and construction details of existing City of Seattle probes are presented in the "Draft Environmental Impact Statement for Midway Sanitary Landfill Closure,", (Seattle Engineering Dept, August, 1985) and selected probe locations are also indicated as "existing" probes on Figure 3. Locations of Department of Ecology shallow and deep gas probe clusters are summarized in the draft "Gas Monitoring Report" by Black & Veatch, Feb, 1986. Landfill gas monitoring and sampling to be conducted in accordance with this sampling plan is intended to enhance the existing data base and provide additional data to achieve the objectives of the gas monitoring and sampling task of the remedial investigation.

Gas monitoring will be conducted using the following procedures:

- The new system of shallow gas probes and deep probe clusters and selected existing City of Seattle probes will be monitored in a time-correlated sequence. Exact sequence will be determined by the field monitoring team and approved by Ecology.

- Several discrete rounds of monitoring will be conducted on selected probes including approximately 50 percent of shallow probes and all operable deep probe clusters. Based on the results of ongoing gas monitoring, one or more intensive gas monitoring surveys consisting of several measurements of key parameters in a 24 to 48 hour period may be conducted for selected probes or within selected geographic boundaries. The equivalent of five complete monitoring rounds for all installed gas probes will be completed during the RI monitoring period.

- Measurements at gas probes will include gas pressure and temperature, combustible gas concentration, hydrogen sulfide, oxygen, carbon dioxide, and organic vapor analysis in a survey mode (total organics). In addition, barometric pressure will be continuously monitored at an appropriate location near or at the landfill during gas monitoring activities.

- Organic vapor analysis will be conducted in the chromatographic mode at selected monitored probe locations in order to semi-quantitatively "fingerprint" the VOC gas components.

- Gas samples will be obtained at approximately five (5) of the probe locations with highest organics concentrations or unique chromatographic pattern, during each round of monitoring. Samples will be obtained using an appropriate pumping device in Tedlar air bags or, alternatively, on Tenax resin or activated carbon collector tubes. Samples will be extracted in the laboratory and analyzed for the parameters in Table 7.

- Gas pressure measurements will be obtained with a portable manometer. These measurements will be used to determine if the methane transport mechanism is dominated by total pressures (advective transport), partial pressures (diffusional transport), or a combination of both.

- Carbon dioxide measurements will be obtained with a portable gas detector or detector tubes. The presence of carbon dioxide will help verify that the source of the methane is the landfill.

- o Organic vapor analysis will be completed using a portable organic vapor detector which can be set to measure total organics in a survey mode, or can be attached to a data recorder and set in chromatographic mode to obtain a relative chromatograph, calibrated to a known compound, which will yield a chromatographic "fingerprint" or trace of those organics which elute through the chromatographic column during a preset measurement period. Comparison of chromatographs produced by this method will indicate the relative distribution of organic vapors at various probe locations and will yield quantitative data for those organics which produce a complete trace relative to a standard instrument calibration. Chromatographic data obtained by this technique will be verified by comparison with laboratory GC data from duplicate gas samples.

Data obtained by the above gas monitoring methods and procedures will be analyzed in accordance with task objectives to determine the extent of gas migration, gas characteristics, and gas control system effectiveness.

C. Identification of Gas Migration Conduits

An inventory will be conducted to identify possible migration conduits and accumulation locations for the landfill gas. The inventory will include sewer lines, drainage pipes, buried utility lines, basements, crawl spaces, and culverts. The primary source of information for this inventory will be existing maps and records. A significant amount of buried utility information has been generated during installation of shallow gas probes as each probe site is marked by the local utility locator service. The continuation of this data gathering will concentrate on areas already known to be areas of gas accumulation.

Spot checks of combustible gas concentrations at points identified in the inventory as probable gas accumulation locations will be performed by the remedial investigation field team using a portable gas detector. If any of these additional measurements indicate the presence of combustible gases, recommendations will be made for a more extensive monitoring program to be implemented.

2.4.2 Ambient Air Quality

2.4.2.1 Objectives

An ambient air quality investigation will be performed as part of the remedial activities to be conducted at Midway Landfill. The objectives of the investigation are summarized as follows:

- o define the extent of landfill gas emissions into ambient air on and around the landfill site
- o characterize the composition of the gases emitted by the landfill, with particular attention devoted to identifying and quantifying organic components and compounds containing sulfur
- o estimate exposure levels from landfill gas on both on- and off-site receptors, both for the undisturbed state of the landfill and conditions occurring during remedial investigations
- o development of information to be used in assessing the performance of on-site and off-site gas control systems installed by the Department of Ecology and the City of Seattle as well as information relating to development of additional remedial measures, if required

2.3.2.2 Existing Data

A number of air quality monitoring efforts have been conducted to date at the Midway Landfill site. These have included monitoring of flare gas emissions at the site for use in development of a site safety plan for well drilling and installation activities (Laucks Testing Laboratories, April, 1984), an air quality modeling effort (University of Washington, May 1985), and on-site measurement of combustible gas levels. The results of the monitoring programs indicate that hydrogen sulfide, methane, and a wide variety of organic trace components comprise the landfill gas. The trace components include aromatic compounds as well as many of the "EPA Priority" chlorinated solvents, such as chloroethane, methylene chloride, dichloroethane, trichloroethane, carbon tetrachloride, trichloroethylene, tetrachloroethane, and tetrachlorethylene. Also present in the flare gas are a number of compounds associated with odor problems, including butanoic acid esters and terpenes.

Using results of the sampling of the flare emissions and assumptions regarding flare operations, a standard EPA dispersion model was used by the University of Washington (1985) to estimate offsite impacts of landfill gas emissions. Results of the model predictions were reasonable approximations to observed values for meteorological conditions occurring during sampling.

Further dispersion model predictions were made for the assumed worst-case conditions, which were light northerly winds during slightly stable conditions. These conditions were estimated to occur about 2 percent of the time. Concentrations predicted during these conditions exceeded guideline values for benzene and hydrogen sulfide at off-site locations in ambient air.

Odor problems were addressed in the University of Washington report. Numerous public complaints have been made by individuals residing or working to the east, south, and west of the landfill. Odor complaints have been made during a wide range of meterological conditions, and may be correlated with the efficiency of past flaring operations.

2.3.2.3 Sample Collection and Analysis Rationale

The air quality investigation will include the following work elements:

- o Source monitoring of the City of Seattle gas control system temporary flares or permanent flare (point source)
- o Source monitoring of the existing landfill surface prior to final closure and selected off-site locations with extensive gas emissions (diffuse source)
- o Source monitoring during leachate well installation activities (point source)
- o Ambient air and meteorological monitoring on-site at one fixed monitoring station and one mobile monitoring location on a continuous or semi-continuous basis
- o Ambient air and meteorological monitoring off-site at three mobile

monitoring locations on an event basis

Each of these areas of investigation is described in detail in the following sections. Additionally, because of the threat of fire or explosion caused by combustible landfill gas emissions, initial remedial measures (IRM'S) have been instituted under the air quality investigation task. The IRM's are described in a technical memorandum "Initial Remedial Measure Recommendations - Midway Landfill", Black & Veatch, August, 1985, and include the use of combustible gas instruments to measure gas concentrations in off-site residential and comercial buildings and the temporary closure of one adjacent business. Additional IRM's have since been instituted including additional building evacuations and installation of several off-site gas extraction systems.

A. Source Characterization of Gas Control System and Flare

The City of Seattle has implemented a gas control plan at the Midway Landfill which includes a curtain of gas extraction wells around the perimeter of the landfill attached to a blower system and a terminal flare to burn the collected gas. The system is currently operating in a temporary mode with portable blowers and flares at several locations on-site. When the system is completed, the entire collection system will be connected to a single stationary blower and flare system. It is assumed that this system will be in place at the time of remedial air quality investigations.

The gas collection system will be sampled at an internal collection point which is representative of the homogeneous gas being collected from the entire landfill, to determine pertinent landfill gas characteristics including:

o gas flow rate

o gas moisture content

o gas temperature

o hazardous substances analysis

o hydrogen sulfide (H_2S)

o hydrogen cyanide (HCN)

o hydrogen chloride (HCl)

o carbon dioxide (CO_2)

Gas flow rate will be determined from operating characteristics of the gas control system blower equipment when operating in a normal mode. If necessary, a portable manometer will be attached to the system at an appropriate location and gas flow rate calculated from pressure measurements and other gas characteristics. Gas temperature will be measured at an appropriate location in the collection system. Gas flow rate and temperature may be available from sensors which are an integral part of the gas control equipment. Gas moisture content will be measured by obtaining a sample from the collection system at an appropriate location and absorbing water vapor on an appropriate dessicant material.

Chemical characteristics of the raw gas stream will be determined by both field and laboratory analysis of representative gas samples from the gas collection system. Field analysis will include Drager tube analysis for H_2S, HCN, HCl, and CO_2. Field analysis of organics will be conducted using an organic vapor analysis (OVA) instrument in the chromatographic mode, and a more detailed continuous chromatographic analysis using a self-calibrated portable gas chromatograph attached to the gas collection system. Tedlar air bags, or alternatively, Tenax resin or activiated carbon collection tubes will be used to obtain time-weighted gas samples for hazardous substance confirmation in a laboratory environment. Samples will also be obtained, using an appropriate air sampling technique, for laboratory confirmation of H_2S and HCN concentrations.

The gas flare will be sampled while operating in a normal mode in a downwind direction, at a distance from the flare determined to be sufficient that combustion is complete and radiant heat low enough that sample probes are not affected by the temperature. Samples taken at this location will be used to characterize the post-combustion gas stream prior to complete diffusion in ambient air. The primary purpose of this sampling technique will be to determine efficiency of the combustion process and detect the presence of any uncombusted organics. Field measurement techniques will include use of detector (Drager) tube, the OVA instrument in survey and chromatographic mode, the self-calibrating portable gas chromatograph in real-time mode, and Tedlar air bags or time weighted carbon/resin collection tubes for subsequent laboratory analysis. Parameter list for organics confirmation will be the same as for the raw gas stream.

Two separate sampling events, including a full suite of field and laboratory measurements, will be conducted for the gas collection system and flare.

B. Characterization of Landfill Area Diffuse Gas Emission

The City of Seattle plan for closure of the Midway Landfill includes capping of the entire surface area with a low permeability soil to prevent intrusion of surface water and reduce diffuse gas emissions. The nature and significance of diffuse gas emission from the landfill and adjacent areas has not been investigated to date. It is assumed that implementation of the gas control system will reduce diffuse gas emission but no data is available to determine or estimate the effect of the gas collection system. It is also assumed that final capping of the site will not be accomplished prior to the air quality remedial investigation.

Characterization of diffuse gas emission will be accomplished using an emission isolation flux chamber (described by Radian Corporation, 1984). The use of the flux chamber allows for the determination of the amounts of a single compound or multiple compounds being emitted from a given surface area per unit time. The information obtained from the flux chamber analysis can then be used in predictive models for population exposure assessments (endangerment assessments) and for evaluation and design of remedial action alternatives, including site capping.

Figure 8 illustrates schematically the emission isolation flux chamber. The unit consists of a stainless steel/acrylic chamber with air mixer, thermocouple, ultra-pure sweep air and rotameter for measuring flow into the chamber, and a manifold for sample collection or instrument connection. The unit is designed to be portable. However, at each sampling location, an in-ground stainless steel or acrylic-covered steel collar will be installed for the duration of the test at that location. The use of the collar assures an integral seal for each sampling event.

A minimum of six landfill sampling sites and six off-site sampling locations will be selected to conduct isolation flux measurements. General sampling locations will be selected by consideration of physiography, soil types, areas of known gas emission, and similar site criteria. Exact flux chamber sampling sites will be determined by dividing the general sampling areas into 200' by 200' grids and running OVA GC/FID transects in total organics mode over the grids. If significant points of emission are detected, the sampling point will be the point of maximum gas concentration. If organics are not detected in significant concentrations, sampling sites will be chosen at random within each grid.

In order to determine variations in diffuse gas emission which may be caused by diurnal heating and cooling or barometric pressure changes, at least one sampling site will be operated in an intensive survey mode over a 24 to 48 hour time period. The portable self-calibrating GC/FID detector will be operated in real-time mode to determine changes in gas diffusion rate and composition.

Isolation flux chamber surveys will be conducted in two phases, on-site and off-site, and will be linked to the schedule for other gas emission and air quality investigations so that data from the diffuse gas surveys can be correlated with other relevant data. Surveys will be spread over enough time that seasonal variations in gas emissions can be estimated.

C. Characterization of Air Emissions During Leachate Well Installation

Procedures as described in the site Health & Safety Plan will be fully implemented during installation of on-site leachate monitoring wells. These procedures include continuous monitoring in the "hot" zone around the drill site for combustible gas concentration, hydrogen sulfide concentration, oxygen concentration, and non-methane organics concentration. In addition to the required procedures and continuous measurements, an OVA instrument will be used in the chromatographic mode to "fingerprint" gas emissions from the leachate well borehole at 20-foot intervals during drilling of each borehole. Additionally, on-site meterological and air quality instruments will be utilized to estimate ambient air impacts of leachate well drilling activities. The self-calibrating portable gas chromatograph will be utilized during this period of ambient air measurement to characterize ambient air downwind of the drilling activity on a real-time basis.

D. On-site Meterorlogical and Ambient Air Monitoring

Studies conducted for the City of Seattle (Univ of Washington, 1985) have suggested further monitoring on-site using an upwind-downwind methodology and a standard air quality dispersion model to further characterize ambient air quality and enable prediction of "worst case" off-site air quality constituent concentrations for specified meteorological conditions. Procedures for on-site ambient air monitoring will utilize the recommended methodology to further define on-site ambient air quality during various meteorological and field activity conditions including the following:

- o critical or "worst case" wind direction and velocity as indicated by the Univ of Washington researchers.
- o representative easterly wind direction and velocity (to the east)
- o representative southerly wind direction and velocity (to the south)
- o representative westerly wind direction and velocity (to the west)
- o during on-site leachate well installation activity
- o during on-site diffuse gas emission survey activity
- o during normal gas control system flare conditions
- o during flare-out gas control system conditions, if allowed by local air quality agencies and approved by the City of Seattle

To accomplish controlled on-site ambient air monitoring during these conditions, a complete remote-operated meteorological station will be installed on-site to obtain local meteorological data including: wind direction and velocity, dry and wet-bulb temperature, barometric pressure, precipitation, and pan evaporation. Continuous or semi-continuous data will be collected by meteorological instruments as necessary during the entire period of the remedial investigation. Data will be collected by recordng pen or digital magnetic tape methods as appropriate.

The wind direction/velocity instrument will be attached to a dedicated portable computer which can be used to trigger on-off states for other instruments including an ambient air gas sampler or portable gas chromatograph. The attached air sampler will collect air samples as programmed (wind direction or time-weighted basis) on carbon/resin collector tubes. The portable self-calibrating gas chromatograph when triggered will collect and analyze real-time ambient air samples.

Two additional meteorological/air quality sampling stations as described above (wind direction and velocity only) will be utilized as mobile ambient air quality stations to obtain simultaneous air quality data downwind of the master station. One of these satellite monitoring stations will be installed at appropriate on-site downwind locations during sampling and monitoring events. Samples of ambient air will be collected on carbon/resin collector tubes in the same manner as at the master monitoring station.

Sample sets will be collected for laboratory analysis using carbon/resin tubes as specified below for the proposed monitoring events:

	Monitoring Station	
Event	Master	On-site Satellite
"Worst Case" Wind Direction & Velocity	2 sets	2 sets
Easterly Wind Direction & Velocity	2 set	2 set
Southerly Wind Direction & Velocity	2 set	2 set
Westerly Wind Direction & Velocity	2 set	2 set
Diffuse Gas surveys	1 set	1 set
Normal Flare Conditions	1 set	1 set
Flare-out Conditions (if approved)	1 set	1 set

All samples will be desorbed and analyzed in the labratory for the parameters listed in Table 7. Simultaneous portable GC measurements will be made on a real-time basis during selected events at either the master or satellite monitoring stations.

E. Off-Site Meterological and Ambient Air Monitoring

A satellite meteorological/air quality station including wind direction and velocity and an automated air sampling assembly will be installed at appropriate off-site locations to the east, south, and west of the Midway Landfill to obtain off-site air samples in coordination with the overall air quality investigation. Samples will be collected in the same manner as for on-site air monitoring stations. Three discrete events will be monitored in a sequential manner as follows:

Event	Number of Samples
Easterly Wind Direction & Velocity	2 sets
Southerly Wind Direction & Velocity	2 sets
Westerly Wind Direction & Velocity	2 sets

The duration of sampling events will be programmed to take into account the expected low concentrations of any landfill gas constituents with distance from the landfill.

Meteorological and air quality data will be collected continuously or semi-continuously during the duration of the overall remedial investigation. Meteorological data collected during this period will be correlated statistically with simultaneous data collected at the nearby SEATAC airport. It will then be possible to utilize the long term data base for the SEATAC airport to estimate meteorological conditions for Midway Landfill for events other than those directly measured. These comparisons will be fed as input data to the established air quality model using actual or simulated air quality data to predict a wide range of off-site air quality scenarios, as appropriate.

2.4 IDENTIFICATION OF RECEPTORS

2.4.1 Receptor Field Investigation

2.4.1.1 Objectives

The objectives of this portion of the field investigation will be to identify those populations which are exposed to hazardous substances or conditions emanating from the Midway Landfill site. The objectives include the identification of the types of populations, sizes, and distribution of the populations at risk.

2.4.1.2 Existing Data

The receptor populations can be divided into two broad groups including human population and wildlife resources (including flora and fauna). The draft Environmental Impact Statement for Closure - Midway Landfill completed by the City of Seattle, while addressing closure alternatives, identified on-site and off-site vegetation and wildlife resources within the general remedial investigation study area. The Seattle-King County Department of Public Health provided a list of those residences that have been monitored for combustible gas levels in the Midway area.

2.4.1.3 Data Collection and Analysis Rationale

During the data collection phase of the receptor field investigation, information will be developed describing the number of people in the area who may be at risk from the following factors:

- o gas migration
- o exposure to airborne hazardous substances
- o exposure to or consumption of leachate-contaminated groundwater

The number of employees at nearby businesses will be determined. A review of the vegetation and wildlife inventory included in the Midway Landfill draft Environmental Impact Statement will be conducted to determine the adequacy of the existing data base for evaluating natural resource receptors. Planning documents available from local and state agencies will be reviewed to determine the existing population density within the study area, population movement patterns, and exposure potential. Future growth and development trends will also be reviewed and assessed with respect to potential for new receptors to emerge in the study area.

TABLE 1

APPROXIMATE DEPTHS AND SCREENED INTERVALS
FOR
PROPOSED GROUNDWATER AND LEACHATE MONITORING WELLS

WELL NUMBER	ESTIMATED DEPTH TO WATER (FT)	APPROXIMATE WELL DEPTH (FT)	APPROXIMATE SCREEN INTERVAL (FT)	WORK PHASE
W1 (d,p)	55	95	50-65; 85-95	1
W2 (d,p)	90	130	85-100; 120-130	1
W3 (d,p)	130	170	125-140; 160-170	1
W4	>175	300	270-300	1
W5 (d,p)	120	160	115-130; 150-160	1
W6	150	190	180-190	1
W7	100	110	95-110	1
W8	95	160	150-160	1
W9 (p)	50	60	45-60	2
W10 (p)	80	90	75-90	2
W11 (d,p)	85	125	80-95; 115-125	1
W12 (p)	105	115	100-115	2
W13 (d,p)	140	180	135-150; 170-180	2
W14 (p)	220	230	215-230	2
W15 (d)	180	190	175-190; 210-220	1
W16	125	135	120-135	2
W17	80	90	75-90	2
L1	40	70	35-50	1
L2	80	110	75-90	1
L3	70	100	65-80	1

d = dual completion
p = includes gas probe(s)

Notes: 1. Well depths and screen intervals are based on review of available geologic data.

2. Total depth of borings for leachate monitor wells will be sufficient to characterize till and advance outwash strata below fill material. Borings will be backfilled using appropriate techniques to an elevation above the fill boundary prior to installation of leachate monitor wells.

TABLE 2

APPROXIMATE DEPTHS AND SCREENED INTERVALS
FOR
PROPOSED GAS PROBES

GAS PROBE NUMBER	ADJACENT GW WELL	APPROXIMATE DEPTH (FT)	APPROXIMATE SCREEN INTERVALS (FT)	WORK PHASE
G1	W1	55	10-55	1
G2		100	10-50; 60-100	1
G3	W2	90	10-40; 50-90	1
G4		100	10-50; 60-100	1
G5	W3	100	10-50; 60-100	1
G6		100	10-50; 60-100	2
G7		100	10-50; 60-100	2
G8		100	10-50; 60-100	2
G9	W5	100	10-50; 60-100	1
G10		100	10-50; 60-100	1
G11		100	10-50; 60-100	2
G12	W12	100	10-50; 60-100	2
G13	W11	85	10-40; 50-85	1
G14	W10	80	10-40; 50-80	2
G15		55	10-55	1
G16	W9	50	10-50	2

Note: See Table 1 for information on groundwater wells referenced in this table.

TABLE 3

LABORATORY ANALYSIS PLAN
FOR
GROUNDWATER AND LEACHATE MONITORING WELLS

PARAMETER	UNITS	NO. SAMPLES EACH WELL	POTENTIAL INDICATOR
Conventional Parameters (Including State of Washington Minimum Functional Standards)			
pH	pH	4	Field
Temperature	oC	4	Field
Conductivity	mmhos/cm	4	Field
Boron	mg/l	4	**
Calcium	mg/l	4	
Magnesium	mg/l	4	
Sodium	mg/l	4	
Potassium	mg/l	4	
Iron	mg/l	4	
Magnanese	mg/l	4	
Carbonate	mg/l	4	
Bicarbonate	mg/l	4	
Sulfate	mg/l	4	**
Sulfide	mg/l	4	**
Chloride	mg/l	4	**
Fluoride	mg/l	4	
Total Dissolved Solids	mg/l	4	
Ammonia Nitrogen	mg/l	4	
Nitrite Nitrogen	mg/l	4	
Nitrate Nitrogen	mg/l	4	
Total Kjehdahl Nitrogen	mg/l	4	
Hardness	mg/l CaCO3	4	
Alkalinity	mg/l CaCO3	4	**
Biochemical Oxygen Demand (BOD-5)	mg/l BOD-5	4	
Chemical Oxygen Demand (COD)	mg/l	4	**
Total Organic Carbon (TOC)	mg/l	4	**
Total Organic Halogen (TOX)	ug/l	4	**
Microbiological and Bioassay Methods			
Total Coliform	#/100ml	4	**
~~Microtox~~	% dim.	4	Field

TABLE 3 (CONTINUED)

LABORATORY ANALYSIS PLAN
FOR
GROUNDWATER AND LEACHATE MONITIRING WELLS

PARAMETER	UNITS	NO. SAMPLES EACH WELL	POTENTIAL INDICATOR
CERCLA Hazardous Substances			
Total Cyanides	mg/l	2-4	
Dissolved Metals (Sb, As, Se, Ag, Th, Be, Cd, Cr, Cu, Ni, Pb, Zn)	ug/l	2-4	
Volatile Organics	ug/l	2-4	
Acid Extractable Organics	ug/l	2-4	
Base Neutral Organics	ug/l	2-4	
Pesticides	ug/l	2-4	

Note: 20 new monitor wells, 14 existing monitor wells, and 2 off-site water supply wells to be sampled 4 times each. Parameters marked "Field" will be measured in field. Parameters marked "**" are potential indicator parameters for sampling rounds 2 to 4.

TABLE 4

LABORATORY ANALYSIS PLAN
FOR
STORMWATER MONITORING

PARAMETER	UNITS	NO. SAMPLES	POTENTIAL INDICATOR
pH	pH units	12	**
Specific Conductance	mmhos	12	**
Ions (B,Ca,Mg,Na,K,Fe,Mn,SO4)	mg/l	2	
SO2	mg/l	2	
Fluoride	mg/l	2	
Total Dissolved Solids	mg/l	12	**
Total Suspended Solids	mg/l	12	**
Total Kjeldahl Nitrogen	mg/l	2	
Nitrate Nitrogen	mg/l	2	
Phosphorus as PO4	mg/l	2	
Alkalinity	mg/l CaCO3	2	
Hardness	mg/l CaCO3	2	
BOD-5	mg/l BOD5	2	
Chemical Oxygen Demand (COD)	mg/l	12	**
Total Organic Halogen (TOX)	ug/l	2	
CERCLA Hazardous Substances			
Dissolved Metals (see Table 3)	ug/l	2	
Volatile Organics	ug/l	2	
Acid Extractable Organics	ug/l	2	
Base Neutral Organics	ug/l	2	
Pesticides	ug/l	2	

Note: Based on sampling 2 - 24 hour storm events, with parameters marked "**" to be used as indicators of runoff quality. Indicator parameters will be analyzed from instrument grab samples obtained at 6 hour intervals.

TABLE 5

LABORATORY ANALYSIS PLAN
FOR
SURFACE WATER RUNOFF
AND SEEPS

PARAMETER	UNITS	NUMBER OF SAMPLES SURFACE WATER	NUMBER OF SAMPLES SEEPS
Field parameters			
pH	pH units	25 - 30	20 - 25
Temperature	oC	25 - 30	20 - 25
Conductivity	mmhos/cm	25 - 30	20 - 25
Microtox	% dim.	25 - 30	20 - 25
Conventional Parameters			
(See Table 4 for list)		8 - 10	20 - 25
Fecal Coliform	#/100ml		20 - 25
CERCLA Hazardous Substances			
Dissolved Metals (See Table 3)	ug/l	8 - 10	5 - 10
Volatile Organics	ug/l	4 - 6	5 - 10
Acid Extractable Organics	ug/l	4 - 6	5 - 10
Base Neutral Organics	ug/l	4 - 6	5 - 10
Pesticides	ug/l	4 - 6	5 - 10

TABLE 6

LABORATORY ANALYSIS PLAN
FOR
SURFACE SOILS AT SEEP LOCATIONS

PARAMETER	UNITS	NO. SAMPLES
Grain size analysis		20
pH (saturated paste)	pH units	20
Conductivity (saturated paste)	mmhos/cm	20
CERCLA Hazardous Substances		
Dissolved Metals (see Table 3)	mg/kg	20
Volatile Organics	mg/kg	20
Acid Extractable Organics	mg/kg	20
Base/Neutral Organics	mg/kg	20
Pesticides	mg/kg	20

Note: Soils will be extracted using appropriate laboratory technique prior to analysis.

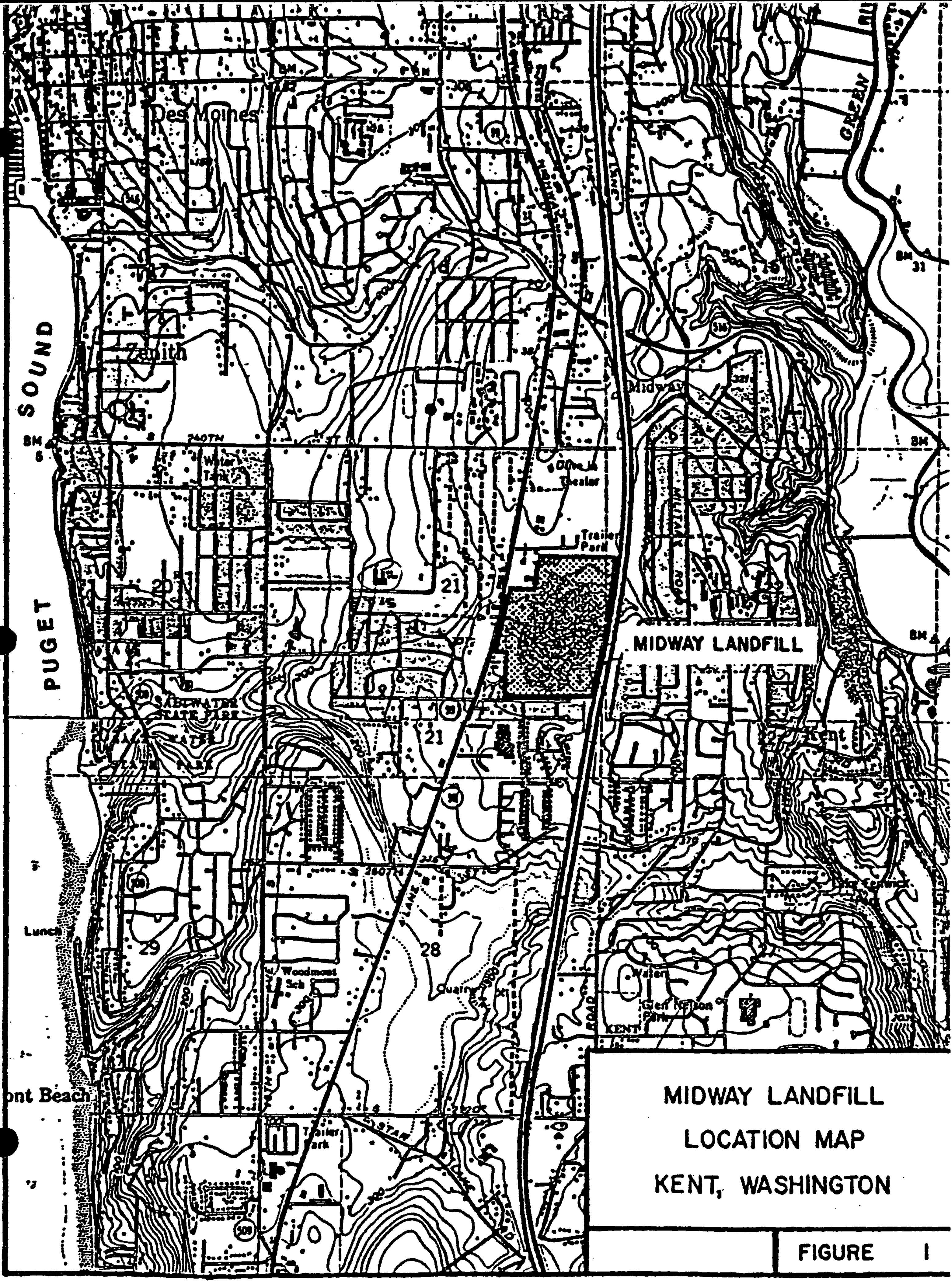
TABLE 7

LABORATORY ANALYSIS PLAN
FOR
LANDFILL GAS AND AIR QUALITY SAMPLES
USING DETECTOR TUBES OR TEDLAR AIR BAGS

PARAMETER	NUMBER OF SAMPLES AMBIENT AIR	GAS PROBES
1,2-Dichloroethylene	28	25
Benzene	28	25
Carbon tetrachloride	28	25
Tetrachloroethylene	28	25
Trichloroethylene	28	25
Toluene	28	25
Chlorobenzene	28	25
Total Xylenes	28	25
Vinyl Cholride	28	25
Methlyene Chloride	28	25

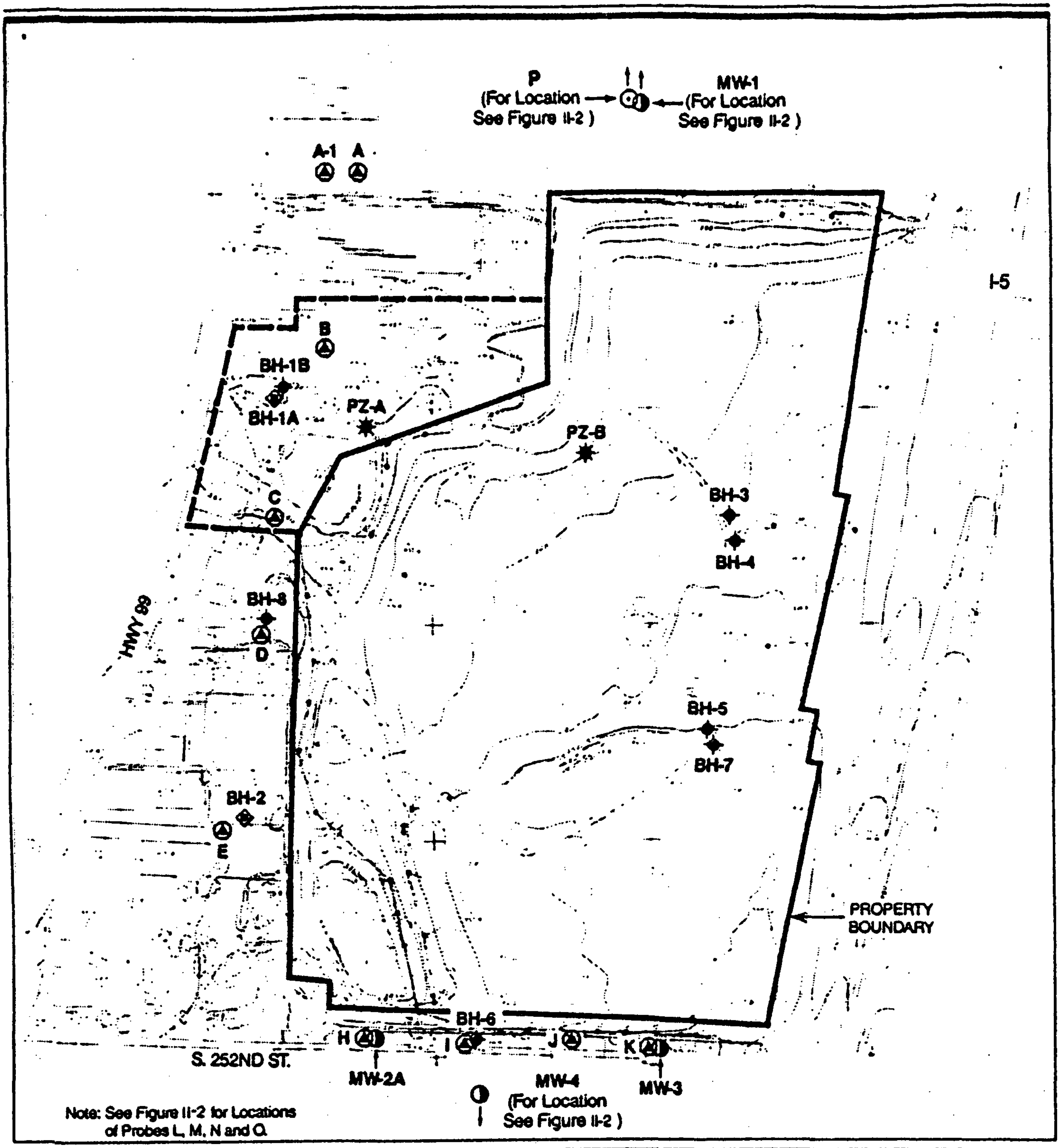
Notes: 1. Parameter list based on historical flare sampling and recent gas probe and ambient air sampling. A complete CERCLA hazardous substances scan for volatile and semivolatile organics will be conducted on samples obtained from the on-site gas control system. Based on those results, additional parameters may be added to the indicator parameter list.

2. Laboratory analysis will consist of sample preparation using cryogenic focusing technique, addition of H20 and standards, and GC/FID or GC/PID with GC/MS confirmation on selected samples.



MIDWAY LANDFILL
LOCATION MAP
KENT, WASHINGTON

FIGURE 1



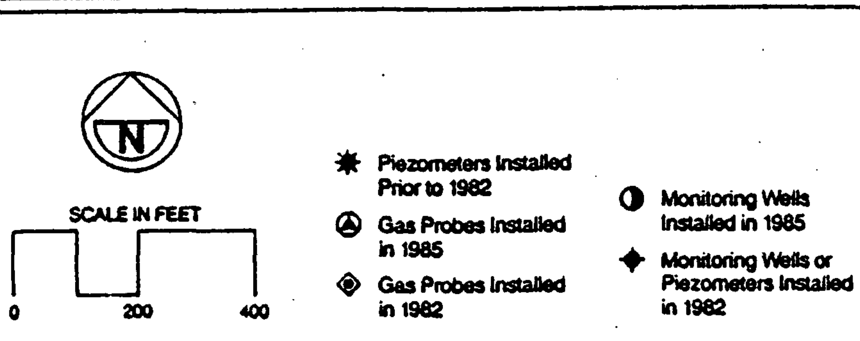
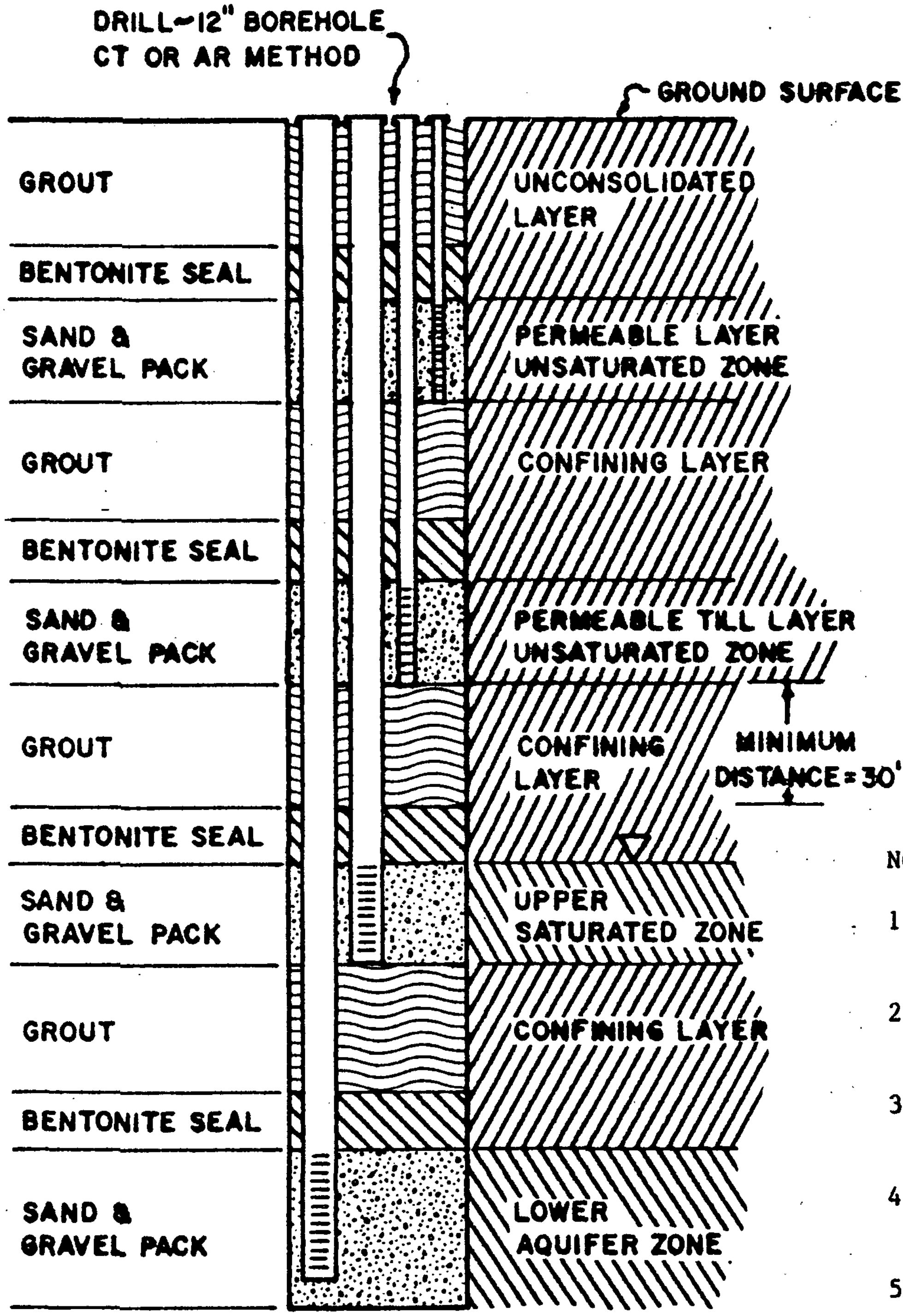


FIGURE 2

LOCATION OF EXISTING MONITORING WELLS, LEACHATE WELLS, AND GAS PROBES



NOTES:

1. BENTONITE SEAL
   MIN. THICKNESS = 24"

2. WELL CASING
   2" ID SCH 80 PVC

3. PROBE CASING
   3/4" ID SCH 80 PVC

4. SCREENS = 0.02" SLOTS
   SCH 80 PVC

5. GROUND FLUSH
   LOCKING MONUMENTS

FIGURE 4

TYPICAL CLUSTERED

WELL/PROBE INSTALLATION

NO SCALE

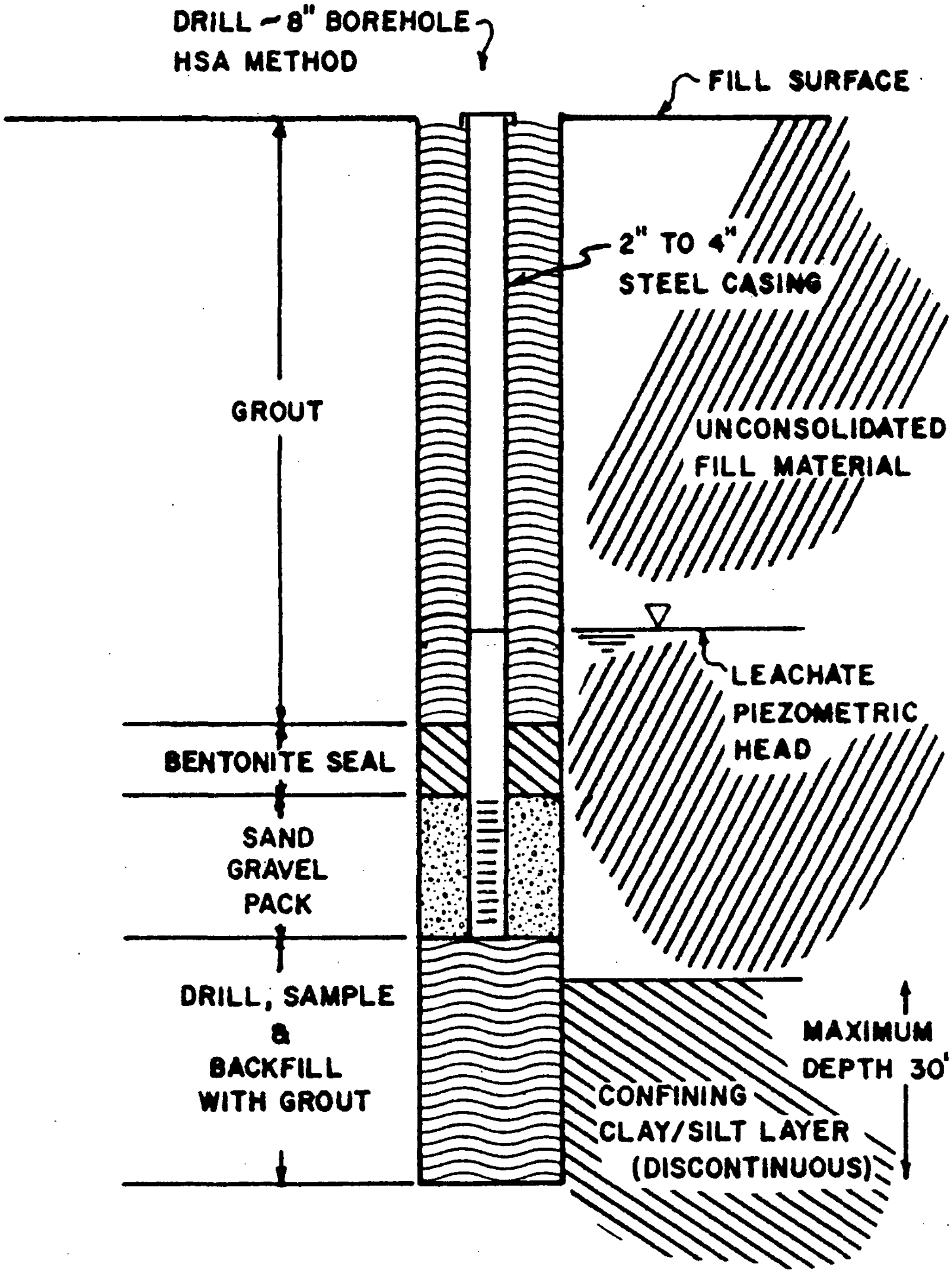
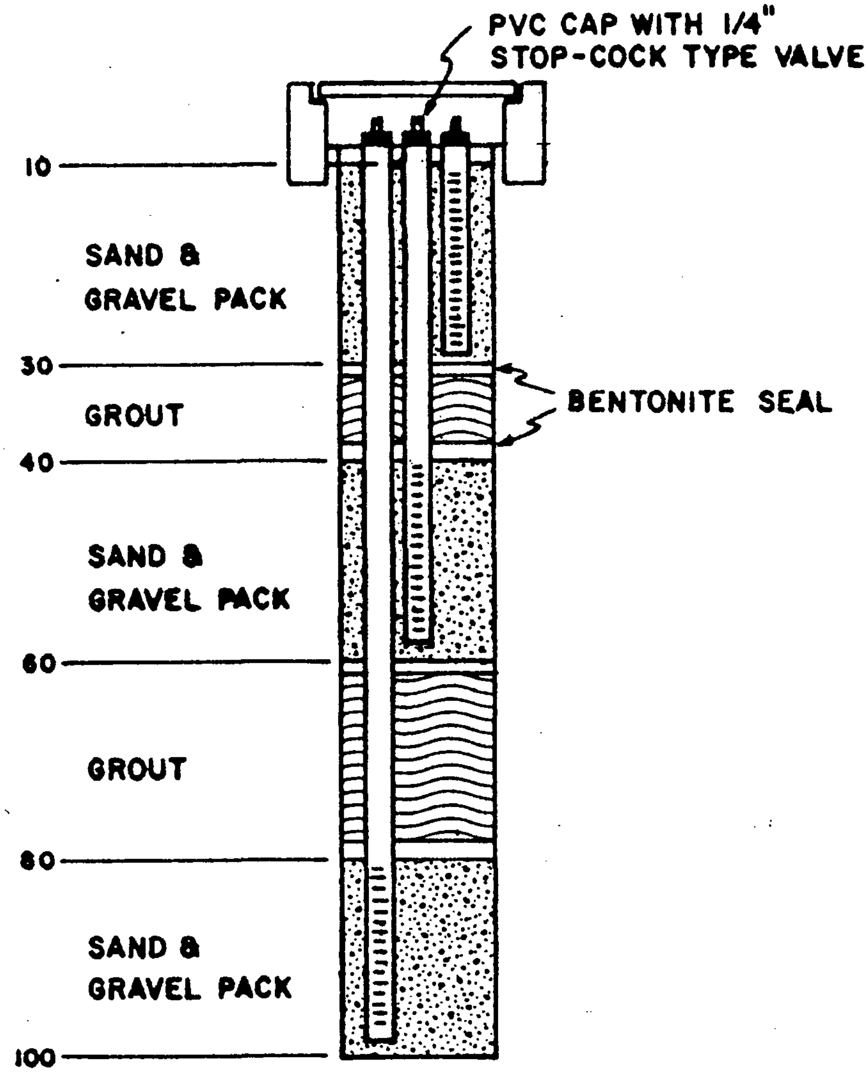


FIGURE 5

TYPICAL LEACHATE WELL
<u>INSTALLATION</u>
NO SCALE



NOTES:

ALL PROBES CONSTRUCTED WITH 1/2 TO 3/4 INCH ID SCH 80 THREADED PVC CASING. SCREEN WILL BE THREADED PVC WITH 0.02 INCH SLOTS.

FIGURE 6

INTERMEDIATE DEPTH
GAS PROBE INSTALLATION
NO SCALE

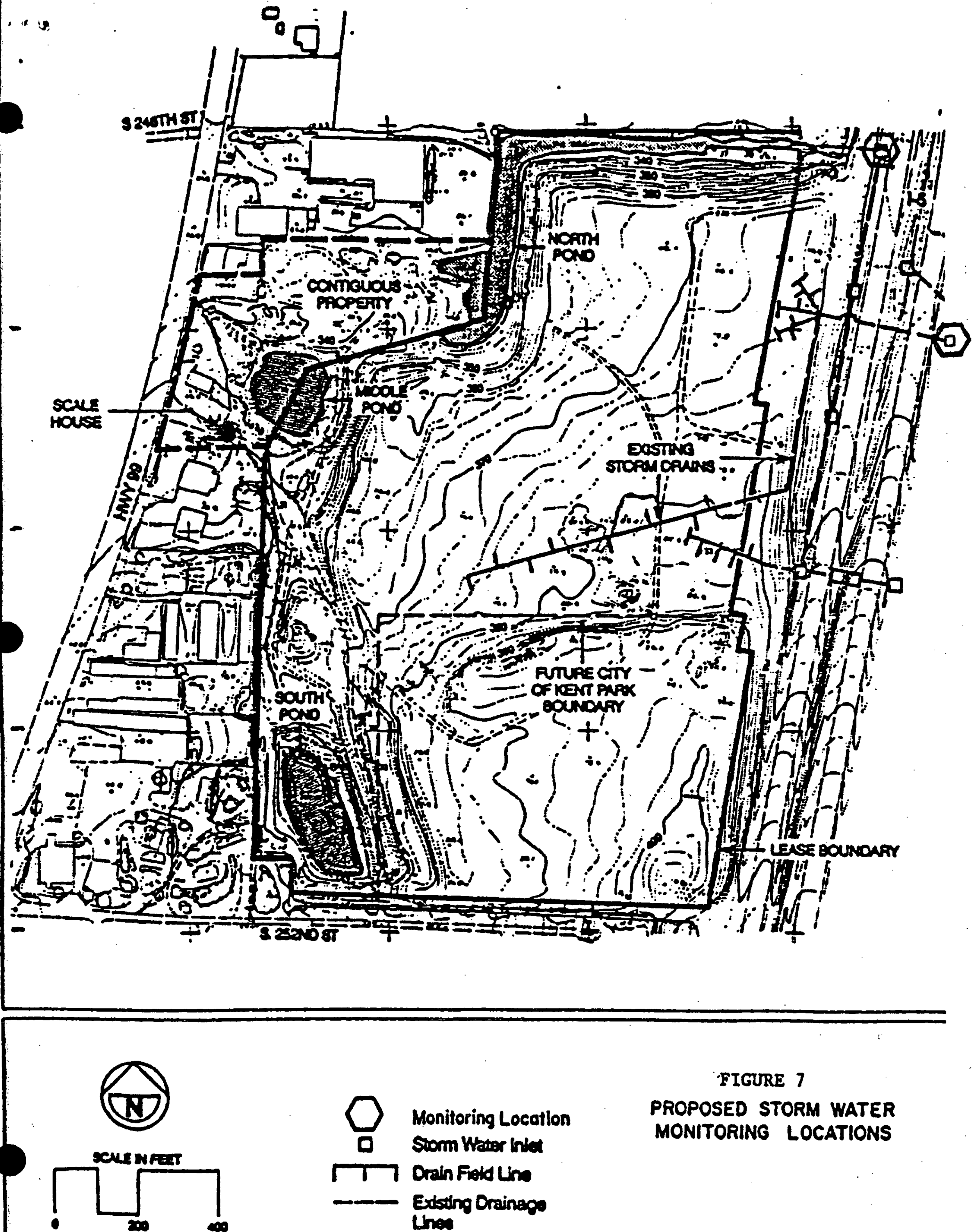


FIGURE 7

PROPOSED STORM WATER MONITORING LOCATIONS

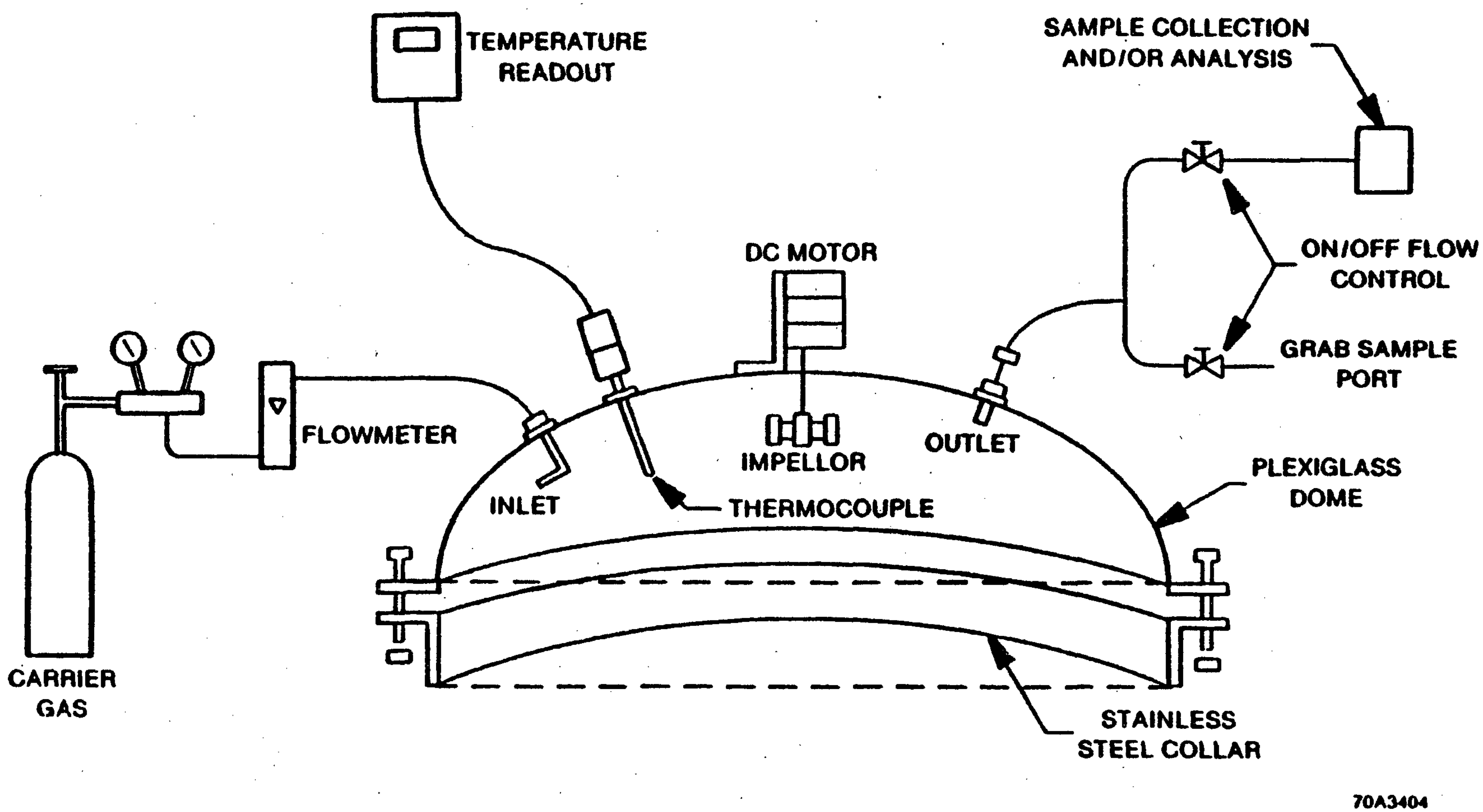


Figure 8 Cutaway Side View of Emission Isolation Flux Chamber and Sampling Apparatus

(form Radian Corporation, 1984)